CONFIDENTIEL

06948

O/Ref. : 6703

Title : Method for controlling the emission power of a transceiver in communication with another transceiver

Applicant : MITSUBISHI ELECTRIC INFORMATION TECHNOLOGY CENTRE EUROPE B.V.

Inventor : JECHOUX Bruno

Filing date : May 27, 1999

Application No : 99 401272.2

The present invention relates to a method for use in controlling the emission power of a transceiver which is in communication with another transceiver, for use for example in a wireless communication system.

Reference will now be made to Fig. 1 of the accompanying drawings which shows a transceiver 10 in communication with another transceiver 20 via a wireless communication system. Transceiver 10 is for example located in a base station and transceiver 20 in a mobile station. Data are exchanged between the transceiver 10 and the transceiver 20 via a wireless interface, a so-called radio channel. In Fig. 1, the transceiver 20 receives from the transceiver 10 a radio signal references as *RC* and sends to the transceiver 10 a radio signal with a power referenced as *P*. The same is for transceiver 10.

The characteristics of radio channels (for example: phase and amplitude) change continuously, due to variations in the geographical environment between a mobile station and a base station. These variations can be separated into free space

propagation losses, slow fading and fast fading losses. Free space propagation losses depend on the path length between the transmitter and the receiver and can be modelled by a d^{-n} law where n is a number between 2 and 4 and d is the path length. Slow fading losses are due to shadowing occurring when obstacles, such as buildings, trees, etc., are interposed between the transmitter and the receiver. Slow fading losses are known to generate variations in channel power for movements that are in the order of 10 times the wavelength of the radio signal. They can be modelled by a log normal law the standard deviation σ of which ranges between 4 and 12 dB depending on the kind of environment. Finally, fast fading losses are due to multipath effect in which a signal follows different paths and the resulting received signals recombine at the receiver entrance with different delays, amplitudes and phases. They can be modelled by a Rayleigh distribution. Movements that are in the order of 1/100 of the wavelength of the radio signal are sufficient to generate fast fading.

Most telecommunication systems use power control methods to limit interference and power consumption. Power control methods aim to command an emission power of both transceivers as close as possible to the minimum needed for a defined quality of transmission.

Such a method includes, carrying out in an evaluating unit 200 of a transceiver (here the transceiver 20), the steps of measuring the received power of the radio signal *RC* (or its amplitude) and, on basis of the result of this measurement, of evaluating a power control command *PC*. The power control command *PC* is used to command a transmission unit 210 so that it transmits signals with a power *P* corresponding to the command *PC*.

Note that the transceiver 10 comprises also such an evaluating unit and a transmission unit.

Due to the time duration (referenced as t_d in the following description) between the moment of the input amplitude measurement (made in the evaluating unit 200) and the moment of the use of the control command signal *PC* to command the emission power *P* (made in the transmission unit 210), the power control methods are based on a measurement and an evaluation which are made during reception and which are used to determine the power to be transmitted during the next emission.

The value of the time duration t_d is imposed by the system for given periods and thus is known by the considered transceiver.

The emission power P is applied with a certain delay t_d after the measurement has been made by the evaluating unit 200; hence the channel features can have significantly changed between the evaluation and the application of the PC command. The power control command PC then wrongly compensates the channel variations, particularly in the case of fast fading losses, where the stronger the fading is, the quicker it disappears.

The object of the present invention is to overcome the above-mentioned problem and then to propose a method for adaptive power control, which can be used in communication systems wherein the power control delay is longer than the time needed for significant variations in channel features to occur.

To this end, a method for controlling the emission power of a transceiver in communication with another transceiver of a communication system according to the present invention includes the steps of evaluating the fast fading duration and of deducing the power control command from the fast fading duration on basis of the amplitude or the power measurement made by the receiver.

According to another feature of the invention, the method includes, for deducing the power control command, the step of comparing the evaluated fast fading duration with the time duration between the amplitude or the power measurement and the emission power setting, and according to the result of the comparison, in determining said the power control command.

According to another feature of the invention, the method includes the step of setting the control command signal PC at the inverse of the measured amplitude $1/L_m$ if the fast fading duration t_f is higher than the time duration t_d between the amplitude or power measurement and the emission power setting and at the inverse of the short-term average of the measured amplitude $1/L_{av}$ if it is equal to or lower than said time duration :

$$PC(t_d) = \begin{cases} 1/L_m & if\ t_f \succ t_d \\ 1/L_{av} & if\ tf \leq\ t_d \end{cases}$$

The aforementioned features of the invention, as well as others, shall become clearer on reading the following description of an embodiment, said description being made with reference to the attached drawings, in which:

Fig. 1 is a schematic diagram illustrating a communication system provided with a power control system,

Fig. 2 is a block schematic diagram of an evaluating unit of a transceiver in a communication system provided for carrying a method according to the invention, and

Fig. 3 is a graphic illustrating the received amplitude with time for use in explaining the method according the invention.

The method of the invention is applied to a communication system such as the system represented in Fig. 1 and is carried out in the evaluating unit of each transceiver 10, 20 of the communication system. Only, the evaluating unit 200 of the transceiver 20 is now considered.

The evaluating unit 200 depicted in more detail in Fig. 2 has a measurement unit 21 for measuring at predetermined times t the amplitude L_m of the received signal RC, a averaging unit 22 for determining the short-term average L_{av} of the measured amplitude L_m, an estimation unit 23 for estimating the fading duration t_f and a control unit 24 for determining the power control command signal PC which is provided for use by a transmission unit 210 to set the emission power P at the value given by the PC command.

Fig. 3 shows the variations with time of the received amplitude L at the receiver 20 input. Downward arrows indicate measurement times made by the evaluating unit 200 and upward arrows indicate the emission times made by the transmission unit 210. At measurement times, the received amplitude is the measured amplitude and is noted L_m. The dotted line represents the short-term average of the measured amplitude L_m that is then noted as L_{av}. The received amplitude L is representative of the free space fading, of the shadowing fading and of the fast fading. The short time average amplitude L_{av} is representative of only the free space fading and the shadowing fading.

Note that the short-term amplitude L_{av} is defined as being the average of the measured amplitude Lm over time periods corresponding to the variation time of the slow fading essentially due to shadowing.

The fading duration t_f is defined as being the average time for which the received amplitude L will stay below the measured amplitude L_m if said measured amplitude L_m is lower than the short-term average amplitude L_{av} or above the measured amplitude L_m if said measured amplitude L_m is higher than the short-term average amplitude L_{av}.

In order to optimise the confidence level of the power control, the method according to the invention determines the power control command signal regarding the estimated fading duration t_f derived from the fading depth L/L_{av}. In other words, the power control command value $PC(t_d)$ is equal to the inverse of measured amplitude if the fading duration t_f is longer than the delay t_d between the moment of the amplitude measure made by the evaluating unit 200 and the application of the power control command $PC(t_d)$ to the transmission unit 210 and is equal to the inverse of the average amplitude L_{av} if it is shorter:

$$PC(t_d) = \begin{cases} 1/L_m & if\ t_f \succ t_d \\ 1/L_{av} & if\ tf \leq t_d \end{cases}$$

Note that the power control command value $PC(t_d)$ is the value which will be used by the transceiver 20 at the present time + t_d to set the emission power P at the evaluated value $PC(t_d)$.

In Fig. 3, at time t1, the fading time tf is shorter than the time duration t_d. Hence, the power control command $PC(t_d)$ is the inverse of the short term average amplitude $1/L_{av}$. It is the same for the time t3. At time the t2, the fading time t_f is higher than the time duration t_d. Hence the power control command $PC(t_d)$ is the inverse of the measured amplitude $1/L_m$. It is the same is for time t4.

Note that the fading duration is too short to impact upon the emission for cases t1 and t3 but it is long enough to do so for cases t2 and t4.

The method of the invention gives an adaptive amplitude correction able to balance fast fading as well as shadowing and free space losses, since the short-term amplitude average L_{av} correct shadowing and free space channel variations.

Note that the estimation unit 23 needs the value of the speed v of the transceiver 20 relative to the transceiver 10 to evaluate the fading duration t_f. A dedicated unit (not shown) can determine or evaluate and deliver this value.

From a publication of Gans in IEEE Trans. Veh. Technol., Vol. VT21, February 19972, pp.27-38, the fast fading duration can be estimated in the following way:

$$t_f = \begin{cases} (a) & \dfrac{\lambda}{\sqrt{2\pi}\,\bar{L}v}\left[e^{(\bar{L}^2)} - 1\right] \qquad \text{if } \bar{L} \prec 1 \\ (b) & \dfrac{\lambda}{\sqrt{2\pi}\,\bar{L}v} \qquad \text{if } \bar{L} \geq 1 \end{cases}$$

where $\bar{L}$ is the measured amplitude L_m at a measurement time normalised by the short-term average amplitude L_{av} ($\bar{L}=L_m/L_{av}$), v and λ are respectively the speed of one transceiver 10 relative to the other 20 and the wavelength of the carrier used by the communication system.

The power control command $PC(t_d)$ can be now given by the following scheme:

$$PC(t_d) = \begin{cases} 1/L_m \begin{cases} \text{if } \bar{L} \prec 1 \text{ and } t_d \prec \dfrac{\lambda}{\sqrt{2\pi}\,\bar{L}v}\left[e^{(\bar{L}^2)} - 1\right] \\ \text{if } \bar{L} \geq 1 \text{ and } t_d \prec \dfrac{\lambda}{\sqrt{2\pi}\,\bar{L}v} \end{cases} \\ 1/L_{av} \begin{cases} \text{if } \bar{L} \prec 1 \text{ and } t_d \geq \dfrac{\lambda}{\sqrt{2\pi}\,\bar{L}v}\left[e^{(\bar{L}^2)} - 1\right] \\ \text{if } \bar{L} \geq 1 \text{ and } t_d \geq \dfrac{\lambda}{\sqrt{2\pi}\,\bar{L}v} \end{cases} \end{cases}$$

where $PC(t_d)$ is the power control command which will be used at the present time (assumed to be zero) + t_d, L is the received amplitude, L_{av} is the short-term average of the measured amplitude, t_d is the time delay between the moment of the measurement of the received amplitude L_m and the use of the PC command and $\bar{L} = \dfrac{L_m}{L_{av}}$ is the normalised received amplitude.

A simplified equation can easily be derived:

$$PC(t_d) = \begin{cases} 1/L_m & \text{if } t_d \prec \dfrac{\lambda * \min(\bar{L}, \frac{1}{\bar{L}})}{\sqrt{2\pi}\,v} \\ 1/L_{av} & \text{if } t_d \geq \dfrac{\lambda * \min(\bar{L}, \frac{1}{\bar{L}})}{\sqrt{2\pi}\,v} \end{cases}$$